

# Brain Tumor Detection and Classification Using Machine Learning

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**ABSTRACT:** Brain Tumor segmentation is one of the most crucial and arduous tasks in the terrain of medical image processing as a human-assisted manual classification can result in inaccurate prediction and diagnosis. Moreover, it is an aggravating task when there is a large amount of data present to be assisted. Brain tumors have high diversity in appearance and there is a similarity between tumor and normal tissues and thus the extraction of tumor regions from images becomes unyielding. In this paper, we proposed a method to extract brain tumor from 2D Magnetic Resonance brain Images (MRI) by Fuzzy C-Means clustering algorithm which was followed by traditional classifiers and convolutional neural network. The experimental study was carried on a real-time dataset with diverse tumor sizes, locations, shapes, and different image intensities. In traditional classifier part, we applied six traditional classifiers namely Support Vector Machine (SVM), K-Nearest Neighbor (KNN), Multilayer Perceptron (MLP), Logistic Regression, Naïve Bayes and Random Forest which was implemented in scikit-learn. Afterward, we moved on to Convolutional Neural Network (CNN) which is implemented using Keras and Tensorflow because it yields to a better performance than the traditional ones. In our work, CNN gained an accuracy of 97.87%, which is very compelling. The main aim of this paper is to distinguish between normal and abnormal pixels, based on texture based and statistical based features.

**KEYWORDS:** — CNN, FCM, Medical Image, segmentation, SVM

## I. INTRODUCTION

Medical imaging refers to a number of techniques that can be used as non-invasive methods of looking inside the body [1]. Medical image encompasses different image modalities and processes to image the human body for treatment and diagnostic purposes and hence plays a paramount and decisive role in taking actions for the betterment of the health of the people. Image segmentation is a crucial and essential step in image processing which determines the success of a higher level of image processing [2]. The primary goal of image segmentation in medical image processing is mainly tumor or lesion detection, efficient machine vision and attaining satisfactory result for further diagnosis. Improving the sensitivity and specificity of tumor or lesion has become a core problem in medical images with the help of Computer Aided Diagnostic (CAD) systems. According to [3], Brain and other nervous system cancer is the 10th leading cause of death, and the five-year survival rate for people with a cancerous brain is 34% for men and 36% for women. Moreover, the World Health Organization (WHO) states that around 400,000 people in the world are affected by the brain tumor and quality of images. The contrast adjustment and threshold techniques are used for highlighting the features of MRI images. The Edge detection, Histogram, Segmentation and Morphological operations play a vital role for classification and detecting the tumor of brain. The main objective of this paper is to study and reviewed the different research papers to find the various filters and segmentation techniques, algorithms to brain tumor detection. The various steps of MR imaging like; preprocessing, feature extraction, segmentation, post-processing, etc. which is used for finding the tumor area of MRI-images 120,000 people have died in the previous years [4]. Moreover, An estimated 86,970 new cases of primary malignant and nonmalignant brain and other Central Nervous System (CNS) tumors are expected to be diagnosed in the United States in 2019 [5]. A brain tumor occurs when abnormal cells form within the brain [6]. There are two main types of tumors- Malignant and Benign. Malignant brain tumors originate in the brain, grows faster and aggressively invades the surrounding tissues. It can spread to other parts of the brain and affect the central nervous system. Cancerous tumors can be divided into primary tumors, which start within the brain, and secondary tumors, which have spread from elsewhere, are known as brain metastasis tumors. On the other hand, a benign brain tumor is a mass of cells that grow relatively slowly in the brain. Hence, early detection of brain tumors can play an indispensable role in improving the treatment possibilities, and a higher gain of survival possibility can be accomplished. But manual segmentation of tumors or lesions is a time consuming, challenging and burdensome task as a large number of MRI images are generated in medical routine. MRI, also known as Magnetic Resonance Imaging is mostly used for a brain tumor or lesion detection. Brain tumor segmentation from MRI is one of the most crucial tasks

in medical image processing as it generally involves a considerable amount of data. Moreover, the tumors can be ill-defined with soft tissue boundaries. So it is a very extensive task to obtain the accurate segmentation of tumors from the human brain

## II. RELATED WORK

Many of the researchers proposed many methods, and algorithms for to find brain tumor, stroke and other kinds of abnormalities in human brain using mr images. manoj k kowar and sourabh yadav et al, 2018 his paper “brain tumor detection and segmentation using k- nearest neighbor (k-nn) algorithms ”. They presents the novel techniques for the detection of tumor in brain using segmentation, histogram and thresholding [4]. Rajesh c. patil and dr. A. S. Bhalchandra et al, in his paper “brain tumor extraction from MRI images using matlab”, they focused on meyer's flooding watershed algorithm for segmentation and also presents the morphological operation [5]. Vinay Parameshwarappa and Nandish s. et al, 2018 in his paper “segmented morphological approach to detect tumor in brain images”, they proposed an algorithm for segmented morphological approach [6]. m. karuna and ankita joshi et al, 2017, in his paper “automatic detection of brain tumor and analysis using matlab” they presents the algorithm incorporates segmentation through nero fuzzy classifier. the problem of this system is to train the system by neural network and it desires many input images are used to train the network. the developed system is used only for tumor detection not for other abnormalities [7]. R. B. Dubey, M. Hanmandlu, Shantaram vasikarla et al, 2017, compare the image segmentation techniques in his paper “evaluation of three methods for mri brain tumor segmentation”, they apply preprocessing techniques like; de-noising, image smoothing, image contrast enhancement and comparison of the level set methods and morphological marker controlled watershed approach and modified gradient magnitude region growing technique for mri brain tumor segmentation. they concluded the mgmrgt method gives better result [8]. Sentilkumaran n and Thimmiraja et al, 2017 compare the image enhancement techniques in his paper “histogram equalization for image enhancement using mri brain images”, they presented the study of image enhancement techniques and comparison of histogram equalization basic method like brightness preserving adaptive histogram equalization (AHE), local histogram equalization (IHE), global histogram equalization (GHE), dynamic histogram equalization using different quality objective measures in mri images. they also presented the better result on contrast using bpdhe method [10]. r. preetha and g. r. suresh et al, 2016, in his paper “performance analysis of fuzzy c means algorithm in automated detection of brain tumor” they used fuzzy c means clustering for segmentation. that method given the high computational complexity. fcm shows good performance result in segmented the tumor tissue and accuracy of tumor. segmentation was identified by applied the svm classifier [11]. amer albadarneh, hasan najadat and ali m. alraziqi et al, 2016, [12] proposed the method for brain tumor classification of mri images. the research work applied, based on neural network (NN) and k- nearest neighbor (K-NN) algorithms on tumor classification has been achieved 100% accuracy using K-NN and 98.92% using nn. many researchers has proposed many algorithms and segmentation techniques to find abnormalities in the brain using MRI images. most of them proposed various algorithms to find the abnormality in the brain like brain tumor.

## III. PROPOSED ALGORITHM

In our proposed methodology, there are two distinct model for segmentation and detection of Brain tumor. First model segmented the tumor by FCM and classified by traditional machine learning algorithms and the second model focused on deep learning for tumor detection. Segmentation by FCM gives better result for noisy clustered data set [15]. Though it takes more execution time, it retains more information.

### A. Proposed Methodology of Tumor Segmentation and Classification Using Traditional Classifiers

In our first prospective model, brain tumor segmentation and detection using machine learning algorithm had been done, and a comparison of the classifiers for our model is delineated. Our proposed Brain image segmentation system consists of seven stages: skull stripping, filtering and enhancement, segmentation by Fuzzy C Means algorithm, morphological operations, tumor contouring, feature extraction and classification by traditional classifiers. The results of our work accomplished satisfactory results. The main stages of our proposed model (Fig. 2) will be illustrated in the following sections.

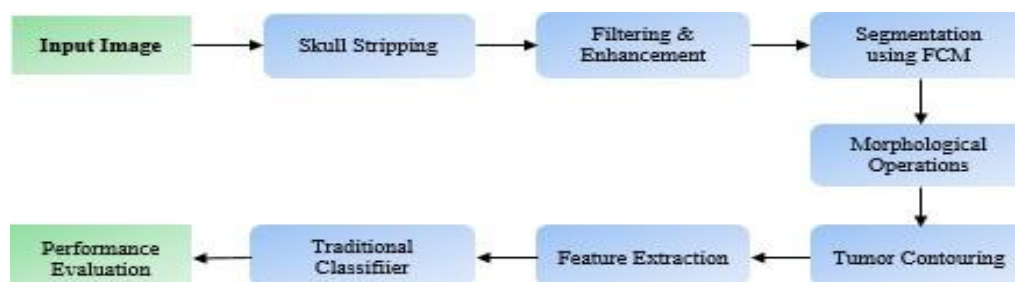


Fig. 2. Proposed methodology for classification using Traditional Classifiers

1)Skull Stripping: Skull stripping is a very important step in medical image processing because of the background of the MRI image not containing any useful information, and it only increases the processing time. In our work, we removed the skull portion from the MRI images in three steps. These three steps are:

- a) Otsu Thresholding: For skull removal, at first we used Otsu's Thresholding method which automatically calculates the threshold value and segments the image into background and foreground. In this method, the threshold that is selected minimizes the intra-class variance, defined as a weighted sum of deviations of the two classes.
- b) Connected Component Analysis: At the last stage of our skull stripping step, we used connected component analysis to extract only the brain region and as a consequence the skull part was removed.<sup>11</sup>

2)Filtering and Enhancement: For better segmentation, we need to maximize the MRI image quality with minimized noise as brain MRI images are more sensitive to noise than any other medical image. Gaussian blur filter was used in our work for Gaussian noise reduction existing in Brain MRI which prevailed the performance of the segmentation.

3)Segmentation using *FCM*: Fuzzy C-Means clustering algorithm was used for segmentation, which allows one piece of data to belong to two or more clusters. We got the fuzzy clustered segmented image at this stage, which ensured a better segmentation.

4)Morphological Operation: To segment the tumor, we only need the brain part rather than the skull part. For this, we applied morphological operations in our images. At first, erosion was done to separate weakly connected regions of the MRI image. After erosion, we will get multiple disconnected regions in our images. Dilation was applied afterwards.

5)*Tumor Contouring*: Tumor cluster extraction was done by an intensity based approach which is thresholding. The output of this image is the highlighted tumor area with a dark background.

6)Feature Extaction: Two types of features were extracted for classification. Texture-based features such as- Dissimilarity, Homogeneity, Energy, Correlation, ASM and Statistical based features including- Mean, Entropy, Centroid, Standard Deviation, Skewness, Kurtosis were extracted from the segmented MRI Images.

7)Traditional Classifiers: We used six traditional machine learning classifiers which are K-Nearest Neighbor, Logistic Regression, Multilayer Perceptron, Naïve Bayes, Random Forest, and Support Vector Machine to get the accuracy of tumor detection of our proposed model.

8)Evaluation Stage: Implementing other region-based segmentation methods and comparing it to our proposed segmentation technique, our model segments the ROI and segregates the tumor portion most accurately. An illustration of the whole process is depicted in Fig. 5. After segmentation and feature extraction from the tumor, we applied six classification techniques. Among them, we got the best result from SVM and obtained an accuracy of 92.42%.

#### B. Proposed Methodology Using CNN

Convolutional Neural Network is broadly used in the field of Medical image processing. Over the years lots of researchers tried to build a model which can detect the tumor more efficiently. We tried to come up with an exemplary which can accurately classify the tumor from 2D Brain MRI images. A fully-connected neural network can detect the tumor, but because of parameter sharing and sparsity of connection, we adopted CNN for our model.

A Five-Layer Convolutional Neural Network is introduced and implemented for tumor detection. The aggregated model consisting of seven stages including the hidden layers provides us with the most prominent result for the apprehension of the tumor. Following is the proposed methodology with a brief narration-

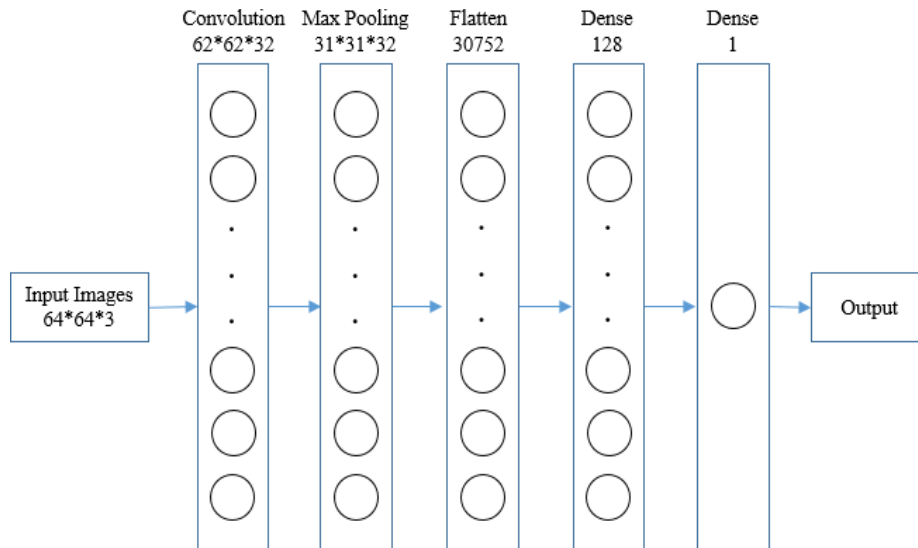


Fig. 3. Proposed Methodology for tumor detection using 5-Layer Convolutional Neural Network

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**Algorithm 1:** Evaluation process of CNN model

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1 loadImage();
2 dataAugmentation();
3 splitData();
4 loadModel();
5 for each epoch in epochNumber do
6     for each batch in batchSize do
7          $\hat{y} = \text{model}(\text{features});$ 
8          $\text{loss} = \text{crossEntropy}(y, \hat{y});$ 
9         optimization(loss);
10        accuracy();
11         $\text{bestAccuracy} = \max(\text{bestAccuracy}, \text{accuracy});$ 
12 return
    
```

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Fig. 4. Algorithm of the performance evaluation

A. Experimental Dataset

For Performance Evaluation of our proposed model, we used the benchmark dataset in the field of Brain Tumor Segmentation, and that is BRATS dataset [16], consisting two classes'— class-0 and class-1 represents the Non-Tumor and Tumor MRI images. 187 and 30 MRI Images containing tumor and non-tumor respectively classified as class-1 and class-0. All the images are MRI images from different modalities like- T1, T2, and FLAIR. For traditional machine learning classifiers, we obtained the superlative result splitting the dataset by 70 to 30 in terms of training to testing images, and for CNN, we divided the dataset in both 70 to 30 and 80 to 20 formation and compared the outcomes.

**B. Segmentation using Image processing techniques**

Based on our proposed methodology, we segmented the tumor without loss of any subtle information. We removed the skull because for tumor segmentation the role of skull is approximately null and ambiguous in this process.

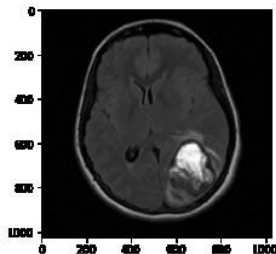


Fig 5.(a)Input Image

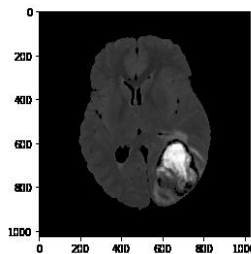


Fig.5(b)Skull Stripping

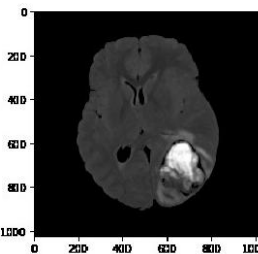


Fig 5(c) Gaussian Filtering

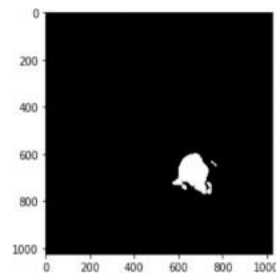


Fig.5 (d) Image Enhancement

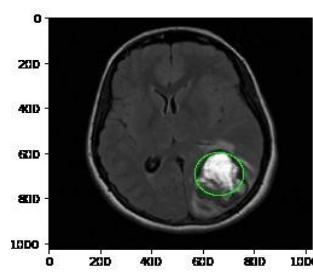


Fig.5(e) Segmentation

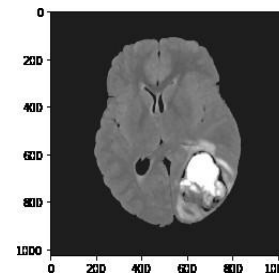


Fig.5(f) Tumor Contouring

From the dataset, a 2D MRI was taken as an input image, Skull stripping technique is performed on the input image (Fig. 1b) followed by image enhancement (Fig. 1c) for understanding the features of the MRI properly. After that, Gaussian filter (Fig. 1d) is used for noise removal and finally simulating the FCM segmentation technique (Fig. 1e) followed by tumor contouring (Fig. 1f) to find out the ROI which is the tumor for Brain MRI. After the segmentation of the tumor, we classified the tumor based on different traditional Machine learning Algorithms.

**C. Classification Using Machine Learning**

Texture and Statistical based features are more popular for detecting the Region of Interest (ROI). Based on these features we can segregate the tumorous and non-tumorous MRI. We used texture and statistical based features for classification. Texture-based features like- Dissimilarity, Homogeneity, Energy, Correlation, ASM and Statistical based features including- Mean, Entropy, Centroid, Standard Deviation, Skewness, Kurtosis were extracted from the segmented Brain tumor. Further, we extracted the Area, Convex Hull Area and Diameter of the tumor. Extrapolating Convex Hull Area and Diameter of the tumor. Extrapolating these features from the segmented MRI, we classified the image as the existence of normal and abnormal tissue.

**D. Classification Using CNN**

The five-layer proposed methodology gives us the commendable result for the detection of the tumor. Convolution, Max Pooling, Flatten, and two dense layers are the proposed five layer CNN model. Data augmentation had been done before fitting the model as CNN is translation invariance.

We evaluate the performance in two ways based on splitting the dataset. We accomplish 92.98% of accuracy for 70:30 splitting ratio where the training accuracy is 99.01%. Then at the second iteration, 80% of the images assigned for training and the rest of the images accredited for testing where we concluded 97.87% of accuracy and 98.47% of training accuracy. So our proposed model gives the best result when the division is 80:20.

We got 97.87% as accuracy which is remarkable in terms of using five-layer CNN. We analyzed with a different number of layers but the divergent of the outcomes were not very significant in terms of using this five-layer CNN model. Some of the aspects that we obtained when we increase the number of layers is- computation time, the complexity of the method batch size and steps per was immensely high. Further, we used 0.2 as the dropout value but did not commensurate

the model as the accuracy flattened. As a result, this model provides the best accuracy without using dropout.

| No | Training Image | Testing Image | Splitting Ratio | Accuracy (%) |
|----|----------------|---------------|-----------------|--------------|
| 1  | 152            | 65            | 70 : 30         | 92.98        |
| 2  | 174            | 43            | 80 : 20         | <b>97.87</b> |

Table 1.PERFORMANCE OF THE PROPOSED CNN MODEL

#### IV. RESULTS

In this work, efficient automatic brain tumor detection is performed by using convolution neural network. Simulation is performed by using python language. The accuracy is calculated and compared with the all other state of arts methods. The training accuracy, validation accuracy and validation loss are calculated to find the efficiency of proposed brain tumor classification scheme. In the existing technique, the Support Vector Machine (SVM) based classification is performed for brain tumor detection. It needs feature extraction output. Based on feature value, the classification output is generated and accuracy is calculated. The computation time is high and accuracy is low in SVM based tumor and non-tumor detection.

In the proposed CNN based classification doesn't require feature extraction steps separately. The feature value is taken from CNN itself. In above table shows the classified result of Tumor and Non-tumor brain image. Hence the complexity and computation time is low and accuracy is high. The output of brain tumor classification accuracy is given in fig.3. Finally, the classification results as Tumor brain or non-tumor brain based on the probability score value. The normal brain image has the lowest probability score. Tumor brain has highest probability score value, when compared to normal and tumor brain.

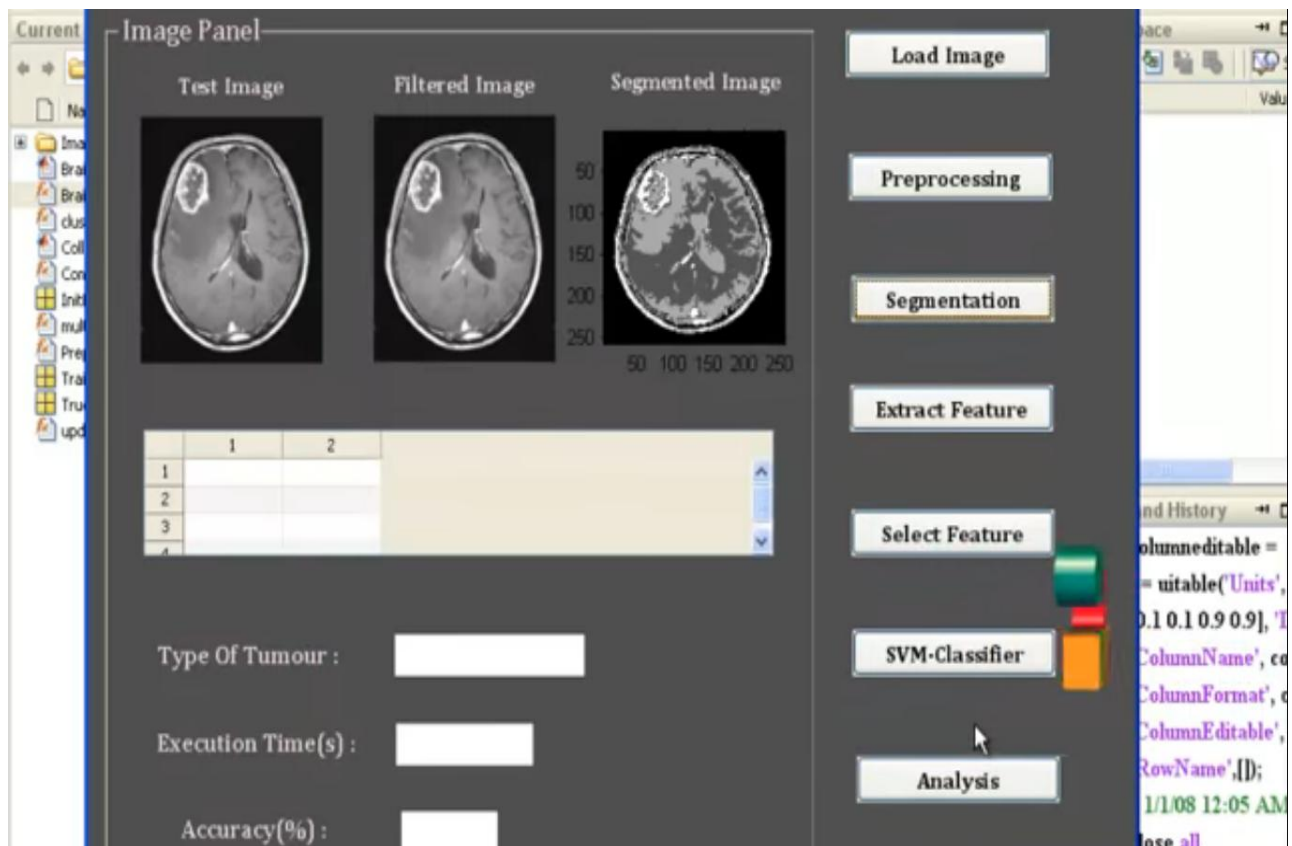


Fig.(6) comparing training and testing MRI images for brain tumor

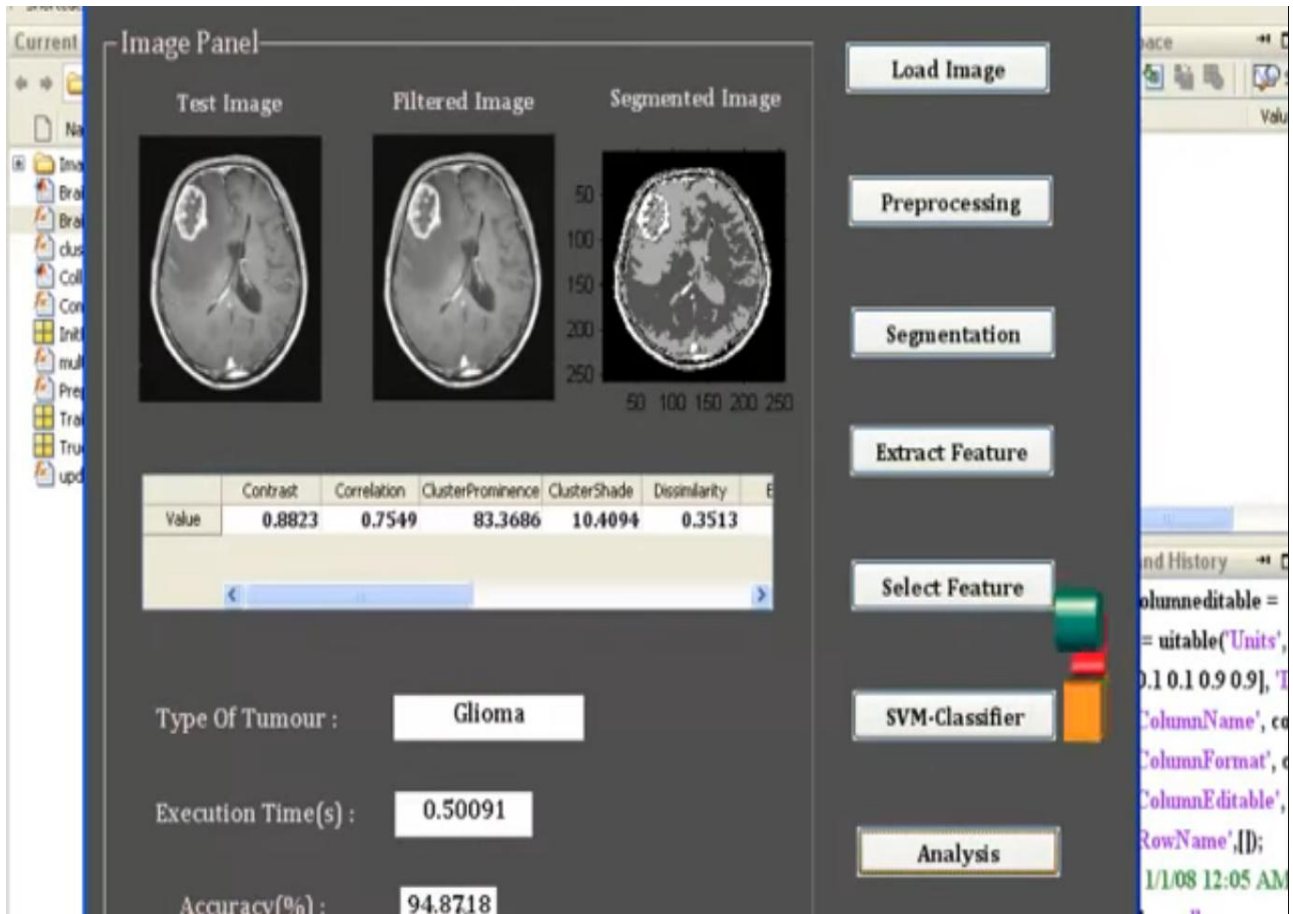


Fig. (7) Final result showing above MRI image has Glioma brain tumor

### V. CONCLUSION AND FUTURE WORK

The aim of the present study was to design, implement, and evaluate a software pattern recognition system to improve classification accuracy between primary and metastatic brain tumors on MRI.

Here, several existing brain tumor segmentation and detection methodology has been discussed for MRI of brain image. All the steps for detecting brain tumor have been discussed including pre-processing steps. Pre-processing involves several operations like non local, Analytic correction methods, Markov random field methods and wavelet based methods has been discussed. Quality enhancement and filtering are important because edge sharpening, enhancement, noise removal and undesirable background removal are improved the image quality as well as the detection procedure. Among the different filtering technique discussed above, median filter suppressed the noise without blurring the edges and it is better outlier without reducing sharpness of the images, mean filter are much greater sensitive than that of median filter in the context of smoothing the image.

Gaussian reduces the noise; enhance the image quality and computationally more efficient than other filtering methodology. After the several image quality improvement and noise reduction discussion here, some possible segmentation methodology like intensity based binarized segmentation, Region based, classification based, texture based, clustered based, neural network based, fuzzy, edge based, atlas, knowledge based, fusion, probabilistic segmentation has been described above with short description, advantage and disadvantage to detect or segment a brain tumor from MRI of brain image. In the threshold intensity based binarized segmentation Kapur method is best methods and produce very effective results. Most of the binarized fails due to large intensity difference of foreground and background i.e. the black background of MRI image.

## REFERENCES

- [1] Kasban, Hany & El-bendary, Mohsen & Salama, Dina. (2019). "A Comparative Study of Medical Imaging Techniques". International Journal of Information Science and Intelligent System. 4. 37-58. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.
- [2] D. Surya Prabha and J. Satheesh Kumar, "Performance Evaluation of Image Segmentation using Objective Methods", Indian Journal of Science and Technology, Vol 9(8), February 2016.
- [3] Brain Tumor: Statistics, Cancer.Net Editorial Board, 11/2017 (Accessed on 17<sup>th</sup> January 2019)
- [4] Kavitha Angamuthu Rajasekaran and Chellamuthu Chinna Gounder, Advanced Brain Tumour Segmentation from MRI Images, 2018.
- [5] General Information About Adult Brain Tumors". NCI. 14 April 2014. Archived from the original on 5 July 2014. Retrieved 8 June 2014. (Accessed on 11<sup>th</sup> January 2019)
- [6] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.
- [7] B. Devkota, Abeer Alsadoon, P.W.C. Prasad, A. K. Singh, A. Elchouemi, "Image Segmentation for Early Stage Brain Tumor Detection using Mathematical Morphological Reconstruction," 6th International Conference on Smart Computing and Communications, ICSCC 2017, 7-8 December 2017, Kurukshetra, India.
- [8] Song, Yantao & Ji, Zexuan & Sun, Quansen & Yuhui, Zheng. (2016). "A Novel Brain Tumor Segmentation from Multi-Modality MRI via A Level-Set-Based Model". Journal of Signal Processing Systems. 87. 10.1007/s11265-016-1188-4.
- [9] Ehab F. Badran, Esraa Galal Mahmoud, Nadder Hamdy, "An Algorithm for Detecting Brain Tumors in MRI Images", 7th International Conference on Cloud Computing, Data Science & Engineering - Confluence, 2017.
- [10] Pei L, Reza SMS, Li W, Davatzikos C, Iftekharuddin KM. "Improved brain tumor segmentation by utilizing tumor growth model in longitudinal brain MRI". *Proc SPIE Int Soc Opt Eng*. 2017.
- [11] Dina Aboul Dahab, Samy S. A. Ghoniemy, Gamal M. Selim, "Automated Brain Tumor Detection and Identification using Image Processing and Probabilistic Neural Network Techniques", IJIPVC, Vol. 1, No. 2, pp. 1-8, 2012.
- [12] Mohd Fauzi Othman, Mohd Ariffanan and Mohd Basri, "Probabilistic Neural Network for Brain Tumor Classification", 2nd International Conference on Intelligent Systems, Modelling and Simulation, 2011.
- [13] A. Rajendran, R. Dhanasekaran, "Fuzzy Clustering and Deformable Model for Tumor Segmentation on MRI Brain Image: A Combined Approach," International Conference on Communication Technology and System Design 2011.
- [14] Sobhaninia, Zahra & Rezaei, Safiyeh & Noroozi, Alireza & Ahmadi, Mehdi & Zarrabi, Hamidreza & Karimi, Nader & Emami, Ali & Samavi, Shadrokh. (2018). "Brain Tumor Segmentation Using Deep Learning by Type Specific Sorting of Images".
- [15] Gupta, Gaurav and Vinay Singh. "Brain Tumor segmentation and classification using Fcm and support vector machine." (2017).
- [16] Anam Mustaqeem, Ali Javed, Tehseen Fatima, "An Efficient Brain Tumor Detection Algorithm Using Watershed & Thresholding Based Segmentation", I.J. Image, Graphics and Signal Processing, 2012, 10, 34-39.
- [17] Seetha, J & Selvakumar Raja, S. (2018). "Brain Tumor Classification Using Convolutional Neural Networks. Biomedical and Pharmacology Journal". 11. 1457-1461. 10.13005/bpj/1511.
- [18] Mariam Saii, Zaid Kraitem, "Automatic Brain tumor detection in MRI using image processing techniques", Biomedical Statistics and Informatics, Vol. 2, No. 2, pp. 73-76, 2017.